

Elements of the Second Event theory Pt II

4. Physical considerations

The second event enhancement factor involves a number of components.

- The proximity of the isotope to the DNA
- The density of ionisation (alpha, beta Auger, slow electrons etc.) This also turns on the half-life of the daughter isotope in a sequence or the activity of a particle.
- The size of the target tissue
- The overall dose i.e. the number of atoms or particles per kg tissue.
- The probability of external irradiation intercepting the same target size of tissue at the same dose. For a 10 μ diameter cell this is very small

Depending on selections of the variables the hazard enhancement can be approximately calculated. It is clear that the enhancement increases rapidly with:

- Decreasing the target size
- Decreasing the overall dose

Thus my original calculations, which were for Sr-90 and Ba-140 anchored to the DNA by chemical affinity for the phosphate, gave enhancements of many orders of magnitude. If the whole cell is assumed as a target and the doses being compared are natural background then the enhancements are modest. For Sr 90/Y-90 the enhancement is about 30 if we assume cell packing based on the rat. NRPB have calculated 1.3 based on cubic close packing of cells and a 300keV event. Table I shows the decreasing probability of hitting a cell twice in 10 hrs for a decay energy of 500keV. These enhancements increase rapidly as the dose is reduced (Table 2).

Table 1. Poisson probability of two 500keV track interceptions separated by 10 hrs on a 10 micron diameter cell subjected to random external irradiation at different annual doses and cell packing based on measurements in rats (Busby 1998).

Annual Dose	Average hits/yr	P(2 hits/yr)	P (2hits/10hrs)
2mGy	1	0.18	2.05 x 10 ⁻⁵
1mGy	0.5	0.076	8.66 x 10 ⁻⁶
0.1mGy	0.05	1.19 x 10 ⁻³	1.36 x 10 ⁻⁷
0.01mGy	0.005	1.24 x 10 ⁻⁵	1.41 x 10 ⁻⁹
0.001mGy	0.0005	2.5 x 10 ⁻⁷	2.9 x 10 ⁻¹¹

Table 2 Excess hazard from internal Sr90/Y90 relative to external irradiation at the same dose.

Dose	2nd event enhancement = P(int)/P(ext)
1mGy	30
0.1mGy (global test fallout region)	200
0.01mGy (local to nuclear sites region)	1900
0.001mGy	9400
1 atom per gram tissue	5 x 10 ⁹